Appendix B
USE OF ACOUSTIC MULTIBEAM SURVEY SYSTEMS ON NAVIGATION, FLOOD CONTROL, AND DREDGING PROJECTS

B-1. Purpose. This appendix disseminates policy for acquiring and using single transducer, shallow-water multibeam survey systems on Corps navigation and flood control projects. It updates EC 1130-2-205 that was first published on 1 July 1996 and expired on 30 June 1998.

B-2. Background. Shallow water multibeam survey systems use a single transducer or pair of transducers to form a fan array of narrow beams that result in acoustic travel-time measurements over a swath that varies with system-type and bottom depth--typically mapping an area 2 to 14 times the channel depth with each array pulse. Multibeam systems can obtain 100% bottom coverage. Multibeam systems can also be configured for waters-edge to waters-edge coverage (i.e., over 180 degree swath), allowing side-looking, full-coverage underwater topographic mapping of constricted channels, lock chambers, revetments, breakwaters, and other underwater structures. Some systems collect acoustic backscatter information and thus produce digital side-scan imagery simultaneously with the swath mapping data, an advantage in locating underwater rock, hazards, or other objects (strike detection). Multibeam acoustic frequencies and signal processing methods may be adjusted to match the survey requirements--dredging measurement and payment, strike detection, structure mapping, etc. Some systems can provide near real-time data collection, filtering, editing, quality assessment, and display; along with near real-time (i.e., on board) data processing, plotting, and volume computations; thus, final plan drawings, 3D terrain models, and dredged quantities can be completed in the field the same day the survey is performed. Multibeam systems have technically advanced since their introduction in the early 1990's to the point that they now have a direct application to most Corps navigation project survey activities. When properly deployed and operated, the accuracy, coverage, and strike detection capabilities of multibeam systems now exceeds that of traditional vertical echo sounding methods.

B-3. Policy.

a. Measurement & Payment Surveys. Multibeam swath survey systems that provide complete bottom coverage are recommended for use in dredging measurement and payment surveys, i.e., plans & specifications surveys, pre-dredge surveys, post-dredge surveys,

and final acceptance/clearance surveys. Multibeam systems are an effective quality control process on dredging projects requiring 100% bottom coverage to assess and certify project clearance. They may optionally be used on dredging projects where less than 100% bottom coverage is required. Refer to Appendix A for recommended bottom coverage and quality control requirements for various types of dredging or surveying projects.

b. Project Condition Surveys. Multibeam survey systems may optionally be used for project condition surveys of channels, revetments, and other underwater structures where complete bottom coverage is desired to fully delineate the feature or structure.

c. Strike Detection. Multibeam survey systems represent an effective mechanism for detection of rocks, wrecks, debris, or other navigation hazards lying above grade in a navigation channel. The side-looking aspects of both the multibeam signal and the digital side-scan sonar imagery signal may be used for such investigation purposes. In order to enhance the probability of detection, and depending on documented system performance characteristics, 200% bottom coverage may be specified in order to insure objects are ensonified from two aspects. Performance demonstration tests on simulated objects should be periodically performed to assure data detection quality and assess the need for overlapping coverage.

d. Emergency Operations. Multibeam systems recording both topographic data and digital side-scan imagery are recommended for locating underwater objects and marking objects for clearing after natural disasters.

e. Other Channel Sweeping Methods. Multiple-transducer, boom-mounted, channel sweep systems are generally preferred for use over multibeam survey systems in shallow-draft (<10 feet), sand/silt-bottomed navigation channels. Multi-transducer systems will also provide 100% bottom coverage on navigation channels, as will mechanical, or manual, channel sweeping techniques and side scan sonar devices. Mechanical bar sweeps remain an effective dredging quality control technique when rock is encountered.

f. Volume Computations. Measurement and payment surveys performed using either multibeam or multiple transducer boom systems shall compute pay quantities using the full, densely populated, data digital terrain models (DTM) generated by swath survey data. Data sets should be thinned to a gridded digital elevation model (DEM) only when multiple or duplicate points

within a specified bin size exist; the representative depth selected within a fixed bin should not be biased or overly smoothed. The bin (or DEM post) size should not exceed either the estimated positional accuracy or the acoustic beam footprint size. The algorithms used for data thinning routines must be thoroughly tested to verify thinned quantities do not differ from raw data set quantities. In effect, data thinning shall be kept to an absolute minimum. Actual dredged quantities should be computed from either the raw DTM or the gridded DEM relative to the applicable payment template using standard CADD software routines. (For sparse data sets, such as traditional single-beam cross-section surveys, dredged volumes may be computed using traditional average end area routines or from triangulated irregular network (TIN) models).

g. Dredging Contract Specifications. Measurement and payment provisions in dredging contract specifications shall clearly stipulate the type of survey system, acoustic frequency, navigation guidance system and software, data acquisition parameters (horizontal and vertical control, density, etc.), data processing and binning techniques, and mathematical volume computational method/software that will be employed by the Government. In order to insure consistency when performing measurement and payment surveys, commercially available software should be employed for data collection, data processing, data quality control, and volume computations.

h. Calibration and Quality Control. Field calibration of multibeam acoustic refractions and vessel motion is significantly more critical and complicated than that required for standard single beam systems. Recommended calibration requirements, procedures, and allowable tolerances are contained in Appendices A and C. Accuracy performance tests are essential in order to demonstrate data quality. These quality control calibrations and quality assurance performance tests must be processed and adjusted on board the survey vessel prior to and during the survey--after-the-fact checks in the district office are of little value. This implies that a near real-time field-finish data collection, processing, editing, and plot creation process must be established in the field in order to insure the most cost effective utilization of this technology.

i. Training Requirements. Multibeam system operators require considerable expertise in both surveying and on CADD work stations. Prior to using multibeam systems on USACE surveys, system operators should have completed specialized training.

Presently, the Corps PROSPECT course on Hydrographic Surveying Techniques is not sufficient for multibeam training. Comprehensive training courses are available from: (1) the University of New Brunswick, (2) Coastal Oceanographics, Inc., (3) Triton Elics International, (4) Odom Hydrographic Systems, Inc., or (5) The Hydrographic Society of America seminars. Multibeam manufacturers may also offer specialized training sessions. In addition, the operator should have completed a manufacturer or Corps PROSPECT course associated with the differential GPS system, inertial compensating system, and CADD processing/editing system employed. For contracted multibeam survey services, the Architect-Engineer (A-E) contract solicitations shall require that proposals identify the experience and training of system operators in Block 7 of the SF 255.

j. Floating Plant. Multibeam systems are normally more cost-effectively utilized on small, mobile (trailerable) survey vessels up to 28 feet in length, with the transducer assembly externally mounted over the side (bow, port, or starboard). Permanent placement on large, non-trailerable, 30 to 65 foot survey vessels is generally recommended only in areas where such a vessel is permanently deployed on a major navigation project.

k. Plant Utilization and Justification. Multibeam surveys may be obtained using hired-labor forces or through A-E service contracts. Commands proposing to purchase multibeam systems shall obtain advance approval from HQUSACE (ATTN: CECW-OD). This approval is necessary to ensure effective and efficient utilization of floating plant, given the $200 K to $500 K investment for a multibeam system. Justifications shall indicate the (1) proposed vessel, (2) system configuration (hardware and software), (3) estimated annual utilization (time and location), (4) FTE allocations, (4) system operator qualifications, (5) field data processing, editing, and plotting, and turnaround capabilities, (6) estimated daily plant and survey crew rental rate, and (7) comparative analyses between hired-labor and contract costs.

l. Data Collection Hardware/Software. Navigation, data collection, and data processing software employed with multibeam systems shall have real-time guidance, display, and quality assurance assessment capabilities. The software shall also be capable of applying all calibrations and corrections in the field such that data can be collected, edited, and processed in near real-time in order to effectively support dredging contract

administration. Software shall also be capable of performing near real-time statistical quality assurance assessments between comparative accuracy performance test models. Strike detection systems may require more high-end PC-based or CADD work stations in order to adequately display and replay 3D imagery in real-time. CADD data thinning or binning routines shall be rigorously tested to ensure data integrity is not adversely modified. This may be accomplished by comparing quantities between raw and thinned data sets.

m. Vessel Positioning Requirements. In general, code-phase, meter-level US Coast Guard differential GPS radio beacons will provide sufficient accuracy for most project surveying applications. It also insures Corps projects are referenced relative to the National Spatial Reference System (NSRS). Where required, translations from NAD 83 to NAD 27 should be performed real-time by the hydrographic data acquisition software. In offshore coastal areas where traditional tidal modeling is deficient, carrier-phase kinematic DGPS (either real-time kinematic (RTK) "OTF" or post-processed) may be needed to enhance vertical accuracy of measured depths. When the multibeam is deployed horizontally to map underwater structures, RTK carrier-phase DGPS may be needed to maintain decimeter-level horizontal accuracy.